Acoustic and Visual Monitoring for Marine Mammals at the Southern California Off-Shore Range

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LONG-TERM GOALS

The goal of this project is to advance acoustic techniques for assessing marine mammal populations. There is a requirement for marine mammal density data within areas of frequent naval operations. The Southern California Off-Shore Range (SCORE) is a region where naval operations are frequently conducted and where marine mammals are seasonally abundant (Figure 1). Acoustic techniques may provide an efficient and accurate method for assessing marine mammal populations in areas of naval interest such as within SCORE.

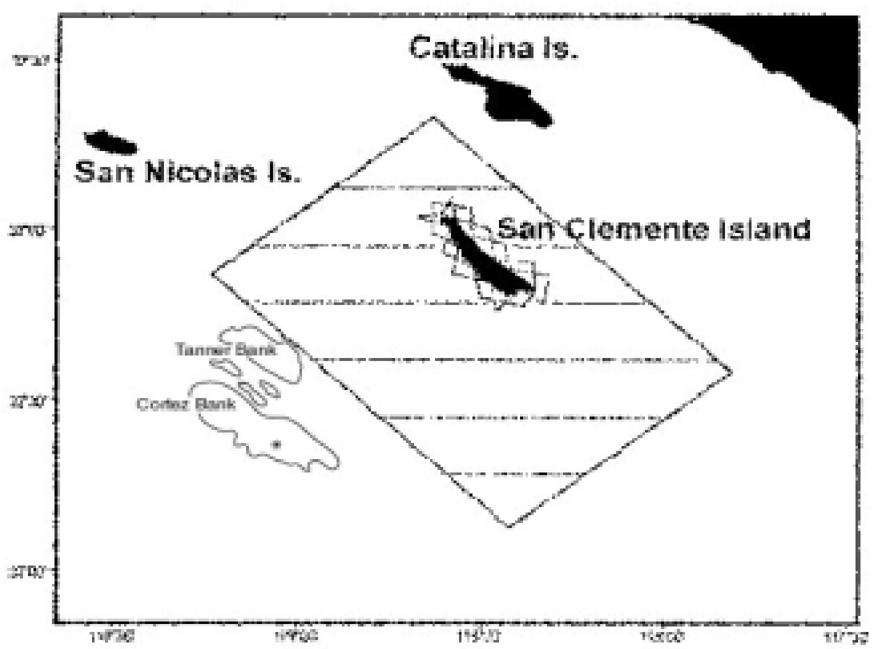

Figure 1. The Southern California Off-Shore Range area (box) and adjacent Tanner and Cortez Banks.

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OBJECTIVES

Our primary objective is to improve methods for acoustic detection and population census for marine mammals. Correlation will be established between acoustic and visual techniques, since visual techniques are the current standard practice for marine mammal population assessment. Finally, we seek to investigate the relationship between satellite environmental data and marine mammal census data.

APPROACH

Several species of marine mammals area known to be both seasonally present and resident in the SCORE area. The following acoustic spectrogram (Figure 2) shows calls produced by blue and fin whales recorded in the SCORE area.

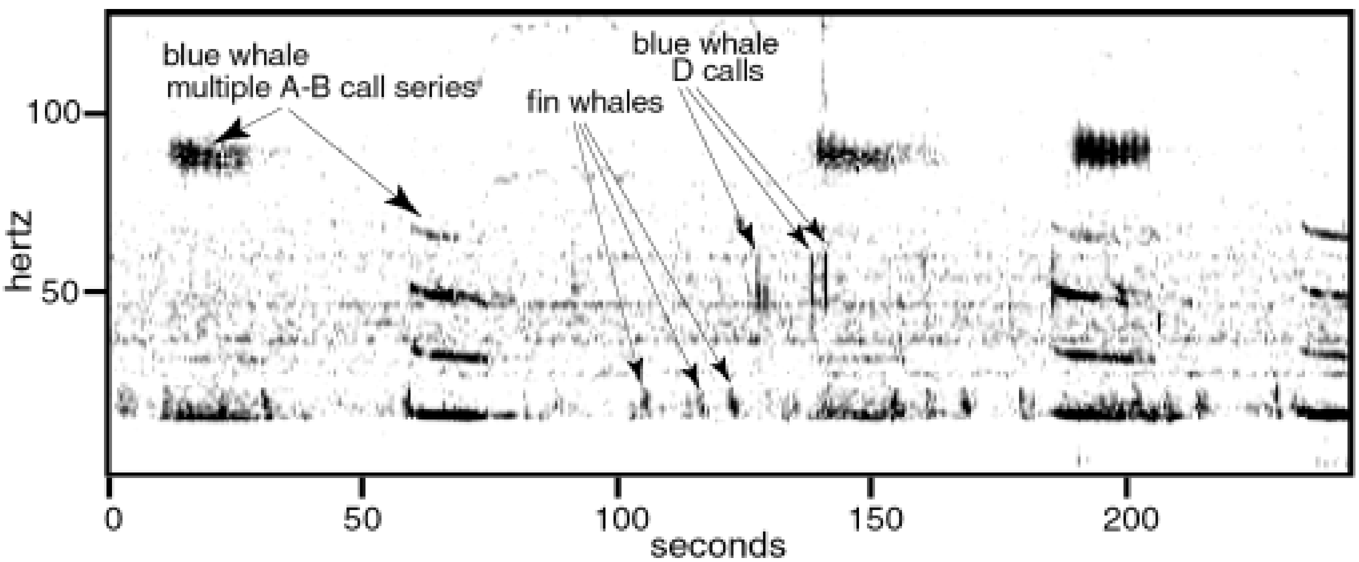

Figure 2. Sonobuoy acoustic data from the SCORE area showing blue and fin whale calls.

To advance acoustic methods for study of marine mammals, we are collecting several acoustic/visual data sets, and we are developing software to allow more efficient analysis of acoustic data for marine mammal calls. The key individuals participating in this work include: John Hildebrand (SIO) -- a specialist in underwater acoustics; Mark McDonald (www.whaleacoustics.com) -- a specialist in marine mammal acoustic monitoring; John Calambokidis (Cascadia Research) – a specialist in marine mammal photoidentification, biopsy, and visual surveys; Jay Barlow (NOAA NMFS) – a specialist in marine mammal population estimation and aerial surveys; and Dave Mellinger (OSU) – a specialist in marine mammal acoustic detection algorithms.

WORK COMPLETED

During FY01 we executed a regular schedule of data collection within the SCORE area that included the following components. (1) Shipboard observations including both visual and acoustic (sonobuoy) surveys were conducted on three occasions (April 28 – May 2; June 18-27; and August 21-30). (2) Aerial visual surveys were conducted on three occasions (May 14; June 11-15; and July 13-20). (3) Acoustic data were continuously collected at three or more seafloor sites within the SCORE region (specifically on Tanner and Cortez Banks). (4) One km resolution satellite data (SeaWIFS) were acquired in the southern California region on at least a daily basis.

The importance of developing automatic call detectors is that these acoustic data sets require significant time to analyze manually. A single day of data (86Mbytes at 500 Hz bandwidth) from a single acoustic recorder requires 5 hours to analyze manually, but can be processed by an automatic call detector in about 5 minutes. Two algorithms for automatic call detection were tested on the SCORE acoustic data: (1) energy summation, and (2) spectrogram correlation. Energy summation seeks the total energy within a specified frequency band and time interval. Spectrogram correlation takes the cross-product of a specified call shape in the spectral domain with the signal spectrogram. To test these algorithms, one day of acoustic data were picked manually and then the detectors processed these data with varying detector threshold levels. The results of this test are shown in Figure 3 as the false detection percentage (non-whale signals triggered the detector) versus the missed call percentage (known whale calls was not detected). The best performance is represented by low values for both these parameters (the lower left-hand corner of the plot).

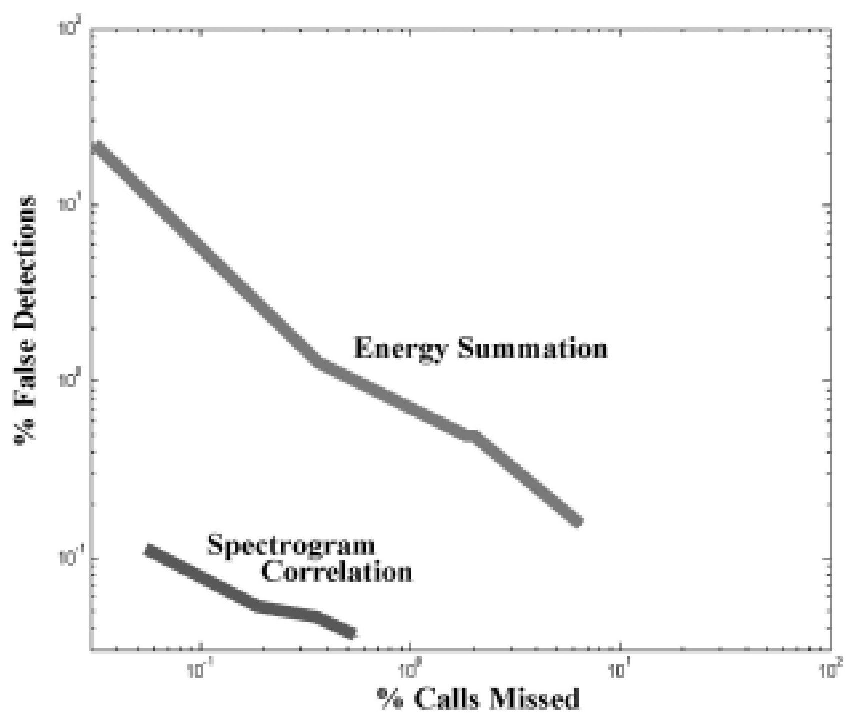

Figure 3. The performance of two methods for automatic call detection are compared. The lines show how each detector rates on false detections and missed calls for varying detection threshold levels. Simple energy summation does only a moderate job (> 10 percent missed or false calls) relative to spectrogram correlation (< 1 percent missed or false calls).

Another way to summarily analyze acoustic data for marine mammal presence is by plotting the spectral energy averaged over long periods of time. For these averages, blue and fin whales can be readily seen as the highest energy source in restricted spectral bands. For instance, Figure 4 shows a one week spectrogram with blue whale energy clearly visible at 17 and 50 Hz, and fin whale energy visible at 20-30 Hz.

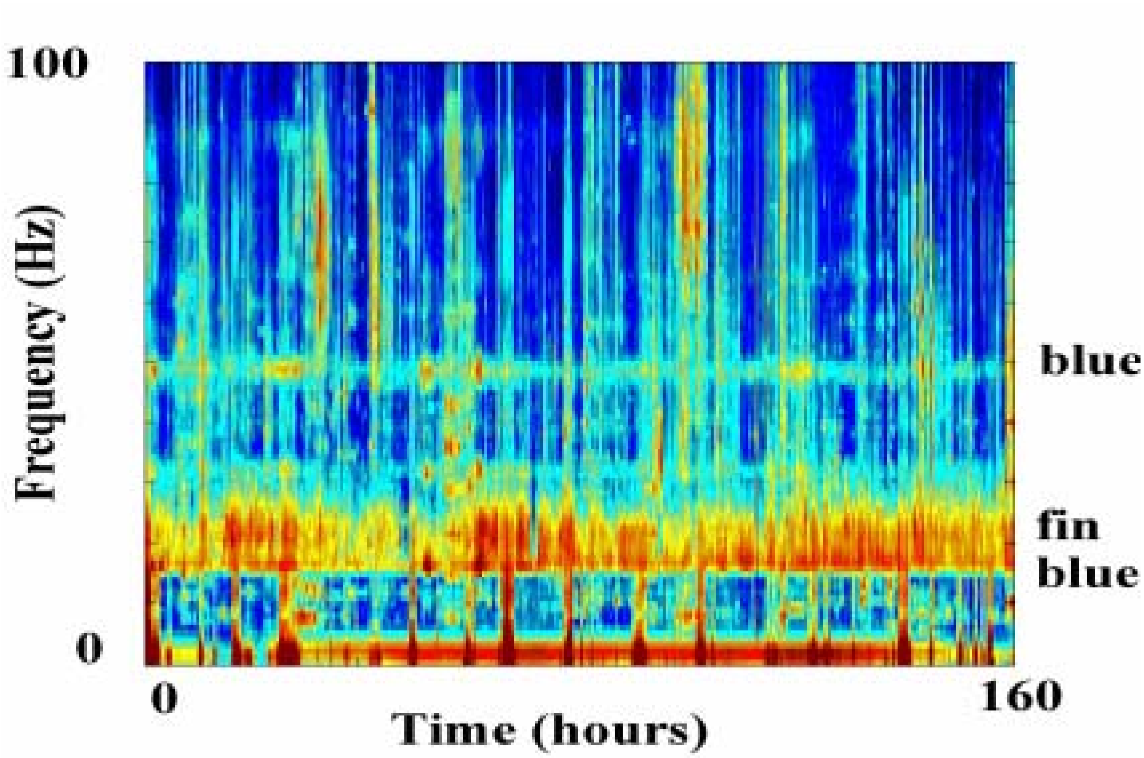

Figure 4. Spectrogram of one-week record for a seafloor acoustic recorder deployed in the SCORE area. The acoustic energy contributions of blue and fin whales are clearly seen in the designated frequency bands.

RESULTS

A key result of this project is the comparison of visual and acoustic data for marine mammal abundance in the SCORE region. One year of acoustic data on blue whale abundance can be summarized by taking weekly averages of the acoustic noise level and then plotting these over a seasonal cycle, as in the lower portion of Figure 5. In the upper portion of Figure 5 we show the results of a one-year aerial survey (flights conducted every two weeks) and a shipboard visual survey (survey cruises conducted every two months). All three data sets suggest that blue whales are present in the SCORE area primarily in the summer season, arriving in mid-May and leaving the area about the beginning of October. The more continuous record presented by the acoustic data may reveal fine details of this process.

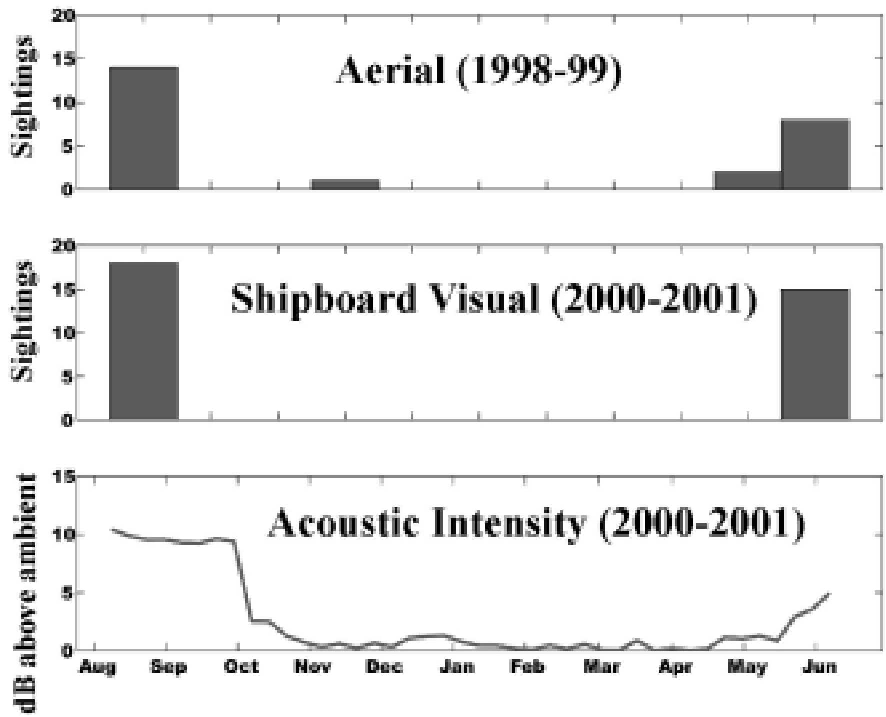

Figure 5. Comparison of blue abundance as measured by aerial survey, shipboard visual survey, and acoustic intensity at 50 Hz relative to background intensity, calculated as one-week averages.

IMPACT/APPLICATIONS

The potential impact of these results is related to the future use of acoustics for marine mammal abundance estimation. Current approaches for marine mammals population estimation rely on visual techniques. Acoustic techniques have the potential to provide more continuous and longer duration records for marine mammal presence. Some of the key problems that are yet to be address relate to the calling statistics for each marine mammal species. What does a particular number of calls (or acoustic intensity level in Figure 5) mean in terms of numbers of calling animals? These are the kind of questions that should be addressed to make acoustic assessments more quantitative.

TRANSITIONS

These results will be helpful to others (such as NOAA-NMFS or naval operations planners) in addressing the problem of assessing marine mammal populations with acoustic data. Specific results for marine mammal presence within SCORE will be useful for understanding potential conflicts in use of the range during peak periods of whale presence.

RELATED PROJECTS

None.